"Human life is present only once; the flowers it will bear in the future have never yet been there. Yet they are present within man in the embryo, even as the flowers are present in a plant that is still only in leaf."

– Rudolf Steiner

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Developing Number Sense Through Imagery

An Intuitive Approach for Children

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Abstract

My thesis examines how intuitive image construction can be integrated into developing number sense. My thesis includes two parts, this written work as well as a production. The production is a children's story- and activity book and its purpose is to develop number sense and intuition through visual imagery. At the end, the book was tested on five children.

The theoretical background aims to serve as a multidisciplinary literary review which reflects the subject into art, pedagogy, and cognitive sciences. In addition to this, it acts as an examination of how the nature of images impacts the learner's spiritual and mental growth. The production works as an example of how the theory might be reflected into a practical educational method.

The process of the thesis was explorative in the sense that the nature of the production was unknown until after the theoretical framework was written. Therefore, the theoretical framework was used as an integral part of the design process, a "toolbox", for the book. Logical and analytical thinking modes are prominent in education. Art is a small portion of the curriculum, and it is seen separate from the rest of education. The integration of art into other subjects is superficial and does not make use of its intuitive, subjective qualities. Visual cognition in mathematics education is developed mostly through ready-made images. The aim of the work is to bring balance to the use of analytical and artistic thinking modes in education.

Through the theoretical framework it was found that intuitive and subjective image construction holds potential in developing cognitive abilities while looking at the student as a holistic entity, not just a head. This might be done through building mental imagery for numbers by imitating the phenomenon of grapheme-color synesthesia.

Keywords: Intuition, learning, mathematics, aesthetic knowing, number-sense, synesthesia

Contents

1. Introduction

Humans consist of a complex mixture of elements which include intuition, cognition, emotions and feelings, to name just some. This complex being does not segregate these different elements from each other, but rather their simultaneous effect produces who we are and how we perceive the world. Therefore, these elements cannot be segregated in education either. Art can be integrated into learning so that a child is able to use more holistically these elements and as a result these elements develop at a balanced rate.

My work deals with just one special case of learning and this is the development of numbersense. Through drawing self-referential images for the numbers from 0 to 10, the child is able to learn the numbers through intuitive and aesthetic experience, while building mental memory aids which help the child cognitively. In this sense, the self-referential quality of learning is of key importance. Knowledge in relation to a certain subject is easily developed through teacher instruction, but the unconscious layers of our experience can only be reached through personal creation.

Colors and forms have the capacity to reach the deeper layers of consciousness, and for each individual they have different effects (Kandinsky 1910). By using them to learn something, we can create a close relationship with our environment and as a result the experience of our environment becomes more meaningful (Steiner 1996). The use of colors and forms in learning also serve as mental aids for memory (see for example Van

Houten & Rolider 1990). This kind of visual thinking in relation to numbers is used by some synesthetes who have a natural tendency to experience numbers in colors, shapes or even personalities. By looking at the ways in which synesthetes build these associations, I explore synesthesia as a possible learning method.

Through this exploration, I designed a children's story and activity book. The book tells a story about a cat and a girl. The girl is having trouble identifying numbers and so the cat teaches them to her through different activities. The reader/listener can complete the activities as the story goes along. The activities can all be completed through creative and spontaneous drawing. At the end of the book, the reader has completed a visual map of his/her personal number images. The construction of the children's book was documented and once finished it was tested on five children.

In this written part of the thesis, I first go over my choice of subject, motivations and goals and explain the thesis process. After this I move on to the theoretical framework in which I first examine the subject from an educational perspective. I then look at the subject from the viewpoint of art and examine the role of intuition in knowledge acquisition. At last, I examine the cognitive backgrounds for the study and think about the possibilities of synesthesia as a learning method. After the theoretical framework, I document the making of the activity book. I discuss the design of the visual style, story and activities of the book. At last, I go over the testing situation and the findings which resulted.

1.1 Motivations

A major inspiration for the topic comes from an article which appeared in Helsingin Sanomat about Daniel Tammet (figure 1), a savant who had severe brain damage to his left hemisphere as a child. As a result, he became able to learn languages exceptionally fast and count complicated math problems in his head in a matter of seconds. (Miettinen 2010.)

The way Tammet counted was very artistic. He had synesthesia, which gave him a highly

Figure 1: Daniel Tammet painting numbers.

sensitized relation to numbers. He could see them as moving visual imagery, and he might describe a number as being "subtle" or "tall". He described the process of multiplication as seeing the two numbers being multiplied as two shapes in his head. When he saw those images, the result "appeared" between them as its own shape, and he immediately knew what number that shape stood for. (Miettinen 2010.)

First, it is very fascinating to read about people with extraordinary abilities because they indicate that humans have many capabilities which are not recognized. Secondly, it made me think that Tammet had all this capacity there even with half of his brain injured. It was only a matter of taking another viewpoint into learning a subject to find all this potential in the brain. In this sense, my thesis is really about going beyond knowledge. I'd like to ponder how we can really stretch the capacities of our thinking.

In addition to Tammet, my thoughts are inspired by the people concerned with the theosophy movement especially the thoughts of Wassily Kandinsky and Rudolf Steiner (who later broke away from the movement to form his own philosophy which he called anthroposophy). Although I don't label myself into these movements, I believe that there is something mystical about human nature, which is a kind of poetical quality that society as a whole cannot see or understand yet. Therefore, I'm not inspired by theosophy directly, but more through the people who were inspired by it and found ways to put theosophical ideologies into use. Kandinsky makes relevant points on the connection of images, their colors and forms, to the soul of an individual. I believe that by decoding information through images, it will pass this inner being and learning will become more natural and effortless. Steiner on the other hand was an advocate in integrating the arts into all subjects. He also talked about the importance of nurturing the inner being of children.

Personal factors influenced my choice of subject. I went to school in the United States from fourth grade until the end of high school. There, the math books were big, heavy and black and white from cover to cover and to me it is no surprise that there are many people there who are not interested in and not good at math. Math was never my passion either, but I think it has a lot of potential to be enchanting in the ways that it creates patterns in the world. I think that if people start to imagine patterns in math that resonate with their inner being, they will find patterns that are important to them, and then maybe they will become motivated to learn math as well. For me, images have been the best way to see these patterns.

Throughout my studies at Aalto University I've been interested in the interconnections of science and art and even more generally the integration

of the rational and intuitive forms of thinking. I believe there are paths where neither of these modes can walk alone, and therefore it requires the open-mindedness of both, to find a mutual understanding. In my thesis I'm concerned with how subjects that are more analytical might be taught as a poetic kind of exploration of the world.

I have been interested from the beginning of my studies in how we gather information about the world holistically, especially in how we might "feel" what we know. In this sense my thesis is a continuation of my BA thesis which was called "Intuitive Information: Ceramics as an aid to visual and tactile learning". I researched tactile learning tools and constructed a ceramic tool (figure 2) where the focus was on learning through touch. The aim was to look at the benefits of multisensory learning and how our hands help us to understand reality. I then designed a tool which is a historical timeline of past learning tools. It consists of images of the tools and on the back of them there are textures made up of dots. The little dots on the back of the timeline are an indication of the time that the object in the front was invented. The denser the dots are, the older the object is. I focused on how visual and tactile methods in learning could make understanding more intuitive and for this I used relative rather than discrete and explicit information. As a result the user can learn quantitative information through intuitive feelings. (Zein 2010.)

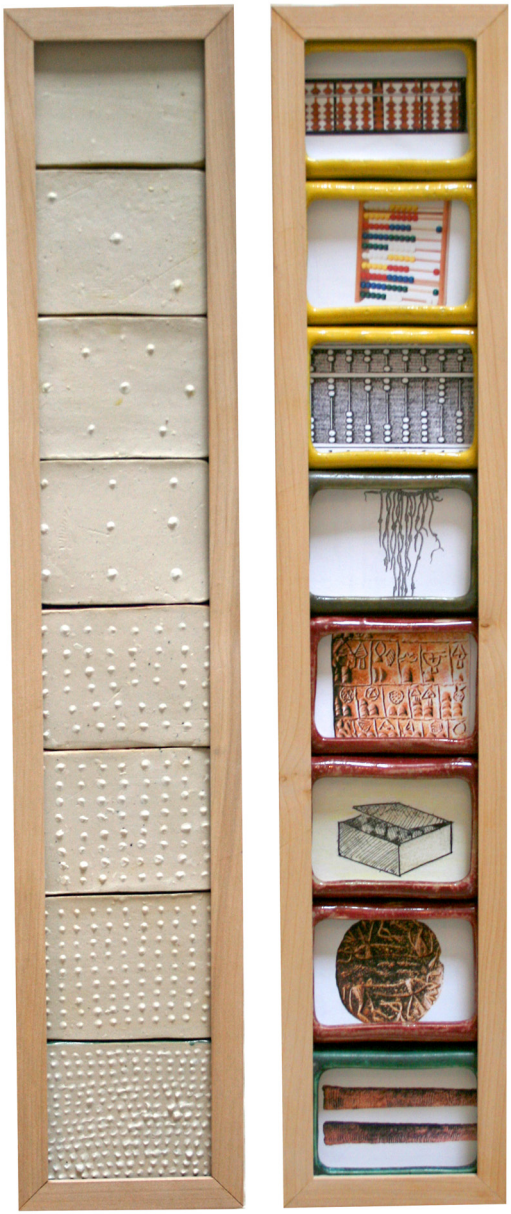


Figure 2: My BA thesis work; a tactile learning tool.

1.2 Goals and Focus of the Study

It seems that education is too focused on analytical and logical subjects. These subjects are often taught verbally and benefit those with an auditory learning mode who think form trees to forests, or details to wholes. As I mentioned earlier, the purpose of this project is to develop intuition and number sense through self-constructed images, so as to balance the analytical atmosphere currently present in education.

The format in which we present information always sets limitations to how we think about that information. Representations are always somewhat biased, and so they do not let the user develop his or her own mental representations which would be most suitable for that individual. In this sense it would be wise to carefully choose the type of presentation to not only promote the type of thinking most suitable for the task, but also to promote the personal mental representations of the individual, and his or her learning style. Therefore, an important goal of the thesis is to give special attention to the subjective experience of the learner and specifically to the learner's experience of their visual imagery.

I appreciate the arts not only for art's sake (which is very important as well) but more so as a general way of being, which includes thinking, knowing and understanding. The arts are a channel to our intuition, and we should use this channel as a resource for information that we can truly rely on and use in our everyday lives. This kind of knowing should be integrated into education instead of being promoted only in art classes. Intuition can be reflected though artistic expression which gives us aesthetic experiences. Therefore the goal is also to develop intuitive knowledge through aesthetic experience.

1.3 Defining the Subject

The reason I am researching especially numbers is practical. I needed to narrow down my subject and I felt that mathematics and numbers are a straightforward way of applying a method that has not been used before, comparing to say, history or languages. There was plenty of research done on the subject in relation to mathematics, and the use of visual imagery in mathematics education was found to be positive.

In this thesis I'm not really concerned about how we might learn elaborate calculations easily. I see no need in this because today I don't have practical everyday use of the fancy calculations I learned in later grades. This is the reason why I'm concerned more with number sense, or very elementary mathematics rather than mathematics having to do with calculations. But despite this I still respect higher mathematics, because it is much more about developing a special kind of thinking than learning about elaborate calculations. It is about seeing patterns

between things and the rhythmic formations of our surroundings. This is why I think visual thinking is especially important in mathematics.

1.4 Methods and Process

I analyze the subject of my thesis through a theoretical background that aims to widen the analysis of the subject through its relation to a larger whole. The production part of my thesis aims to narrow down the subject through a more practical inquiry. Therefore, the theoretical background aims to serve as a multidisciplinary literary review which reflects the subject into art, pedagogy, and cognitive sciences. In addition to this, it acts as an examination of how self-constructed images of information impact the learner's spiritual and mental growth. The production works as an example in how the theory might be reflected into a practical educational method.

I wrote most of the theoretical framework before I designed the book. In fact, there was a period of about 4 months in between writing my theoretical framework and designing my book. This was the most frustrating time of the thesis process, as I had no idea how to bring together the knowledge from the research into a practical, concrete production. Nevertheless, once I was able to integrate the theory into the production it was evident that the theory had become a significant part of the design process. By researching the subject from several different viewpoints I was able to build a concise "toolbox" for myself. The theoretical framework can therefore be seen as an explorative process into the subject which then releases itself into the production.

Nelson and Stolterman (2003, 3) describe the process of design as "a way to approach reality that intentionally embraces its vast richness and complexity". In other words, it could be said that design is a way for evolution to become intentional rather than to be based on chance and necessity which are never predictable. I feel that this approach is close to that which I have used in my thesis.

Perhaps I could describe the process of this thesis as combining freely and creatively different fields but picking from them carefully and intentionally the aspects I want to use. Nelson and Stolterman support this kind of a design process:

> *"In our attempts to design the world to be what we would like it to be, we find that the traditions at hand cannot fully support that task. Science, art, spirituality, economics and technology are all important traditions of inquiry. However, they do not embody the unique specifics of the design tradition, with its corresponding philosophy and praxis. Each of the prevailing traditions has developed a depth of knowledge and insight that is impressive, but it is often focused on a narrow aspect of*

> *our human experience – one that is necessary but not solely sufficient in the management of human affairs." (Nelson & Stolterman 2003, 2.)*

As designers, we create tools to be used in society, by an array of people with an array of uses. We must gather big chunks of information about the surroundings of where our work is situated. Being able to look at the world holistically, with a clear viewpoint and without getting sidetracked into details is, I believe, one of the most important assets of designers. I attempt to do this by looking at subjects holistically, extracting from them the key elements, and reflecting them to each other through my selected viewpoint.

In the beginning of my research, my idea was to design physical learning tools for schools. I soon had to rethink this because it was evident that especially in mathematics mental imagery plays a very big role. Also, students learn in very different ways and one tool will not be beneficial for everyone. For a student to learn optimally, I believe that he or she needs to design these tools for himself/herself, so that individual patterns of thinking are being developed. In this case I can only develop the premises in which the students might design these tools.

2. Theoretical Framework

"Theory, in and of itself, is useless unless it leads us to believe in the interrelationship of phenomena."
- Goethe

This theoretical framework is a multi-disciplinary review on the backgrounds of the methods which were used for the production. I first place the work in the context of a wider perspective. I then look at the educational perspectives for which the production is based on. After this, I examine the integration of art into education as well as the nature of images in learning. I review the kinds of visual imagery used in learning as well as studies on the use of color mediations as mental aids. Last, I look at grapheme-color synesthesia as a phenomenon and ponder its use a possible method in education.

2.1 The Two Cultures and the Two Modes of Knowing

C.P. Snow (1905–1980) was a British novelist and scientist. In his book "The Two Cultures and the Scientific Revolution" he talks about the two opposing cultures of the sciences and the humanities/arts and how they are becoming increasingly separate from each other (Snow 1998, 3). He felt that neither field knew much about the other and that communication was difficult between them. In addition, he believed that the integration of the art and sciences could only happen through rethinking education.

(Snow 1998, 18.) In a speech he gave 4 years later he suggested that a "third culture" is starting to form where these two polarities are joining: "It is probably too early to speak of a third culture already in existence. But I am now convinced that this is coming" (Snow 1998, 71).

In the 1950's and 1960's work by R.W. Sperry and others on the two hemispheres of the brain formed into quite a classic theory of the two specialized functions of the brain. Their research suggested that the left part of the brain takes care of logical, analytical and sequential thinking and that people usually use this part of the brain for verbal and numerical problem solving. The right brain is specialized in holistic thinking and creative processes. It thinks in visual images, special relations and patterns. (West 2009, 25–26.)

The theory was very popular in the 70's and early 80's and it is widely accepted even today, although it is quite a rough and simplified window into the workings of our brains. For example, West talks about the neurologist Norman Geschwind who found that some people had especially symmetrical brains, and that it was this symmetry of the brain which created special talents as well as special areas of difficulty. (West 2009, 25–26.) Research by Olson, O'Boyle and Benbow has indicated that it is the ability to alternate and balance between these two modes of thinking that is the vital trait in creative individuals and gifted children (West 2009, 28, 372). West (2009, 39) also talks about creativity as a "childlike" view of the world, one that often disappears as children grow older and turns into a left-dominant, rigid type of thinking. Children who retain this view can become extremely intelligent.

2.2 Pedagogical Background

In the following section I will present the three major pedagogical perspectives which form the educational background of the study.

2.2.1 Rudolf Steiner and the Waldorf System of Education

Rudolf Steiner (1861–1924) was an Austrian spiritualist who developed the Waldorf system of education. He was also the founder of anthroposophy according to which there is a spiritual world present that is comprehendible to humans and is accessible with the highest faculties of the human mind. These faculties are able to produce knowledge, but remain latent in most humans. (Encyclopædia Britannica 2012.)

The central theme of Waldorf education is to establish balance between the spiritual and worldly. In the same way that C.P Snow (1998) felt about the two cultures, or that Geschwind (1991) felt about the workings of the two hemispheres of the brain, Steiner also believed that human development would enhance

through union. He felt that there was a need to expand the limits of art, science and religion. (Nobel 1991, 221.)

The idea of learning as a subjective experience also reflects the thoughts of Rudolf Steiner. He believed that all education should have its seed in the arts. The best ways to teach children was to tell fairy tales and myths and to let them draw and paint (Nobel 1991, 250.) This is because art acts strongly on the will of the student and reflects the individual as he or she is as a whole being. Steiner believed that the task of education was to find methods of teaching that take in consideration the student as a whole, not just as a head. By concentrating only on the transmitting of physical information, students become heads which are dragging the rest of their being behind them. This being becomes an untamed animal, which start to act on instincts. (Steiner 1996, 7–10.)

To Steiner, numbers lie between the spiritual and the worldly. A merely spiritual knowledge is art. Reading on the other hand is a more physical level of knowledge, as it seeds from writing which has risen from a human activity. Numbers lie between these two. They have a more spiritual nature than letters because the meaning of numbers do not lie in the shapes they have but rather the idea that underlies them which have a more spiritual characteristic. (Nobel 1991, 250.)

Math education should be an area of the soul. It is embedded in human nature to see things as wholes first, and then see the details of that whole. Steiner proposes an example that can be used when teaching children to count. First they should count beans, or cut a piece of paper into 24 pieces. Then they can divide those beans or pieces into different piles consisting of 9, 5, 7 and 3 beans. Like this, the student learns to first see the whole and then its parts. Not only this, the student learns with the whole body. Learning should not happen only with the eyes. When the child learns something, the knowledge should be unconsciously felt in each limb from the head down to the toes, this way the child builds an intimacy with the knowledge. (Steiner 1996, 11–13.)

Steiner believed this intimacy with knowledge to be natural to a child. To Steiner, this was an unconscious process seeded in the human body, while the information was being acquired. It is most beneficial to give children through painting and learning, first the “feeling” and the instinct of knowledge and then the understanding of that knowledge. A child who has gone through an intellectual schooling will know mathematics but will not feel it in his or her soul. (Steiner 1996, 145.) This is perhaps how Daniel Tammet can see his number landscapes – by feeling them in his soul.

Steiner also believed that will, emotion and thinking should always act together. When we teach all subjects through drawing and music, then we are bringing the intellect and the instinctual, sensual experience to the same level (Steiner 1996, 16). When teaching through painting and drawing, children are allowed to discover an interest out of their own being (Nobel 1991, 250).

As we are growing up, this growth is only a continuation of what has happened in the unconscious before a person was born or before the egg was even fertilized (Steiner 1996, 29). Steiner believed that there is no point for teachers to try to study the technicalities of for example, different kinds of memory styles. What is important is to be close to the child's individuality. (Steiner 1996, 76.)

2.2.2 Constructivism

Constructivism is a learning theory that supports the idea of learning as an active process, in other words "learning by doing". Constructivists believe that people create meanings about their surroundings through their own "constructs", or filters of reality. In this theory the learner is seen as a self-directed individual who is creative and innovative. (Educational Broadcasting Corporation 2004.)

The notion of radical constructivism comes from constructivism, but differentiates itself from it by saying that knowledge is always constructed rather than achieved through the senses, and so each person sees the world in his or her own individual way. Therefore, knowledge cannot be simply transferred from the teacher to the students. Instead, the student must build an understanding of the knowledge with his or her own perspective. The transfer of knowledge through language is problematic, because language is learned through associating words with personal experience. Although we adapt our meanings of language to be compatible with that of other people, reading and writing still hold in their core a subjective meaning. (Glaserfeld 1991.)

2.2.3. The Reggio Emilia Approach

"Children only truly understand that which they invent for themselves" – Loris Malaguzzi

The Reggio Emilia educational approach focuses on preschool and primary education. Reggio Emilia is a city in Northern Italy where this pedagogical format was founded after World War 2. After the war, the residents felt the need to rebuild their community and as a part of this process they built a school which was owned and operated by the parents. The parents recruited a teacher, Loris Malaguzzi into this school. Later, several similar schools were formed into the

area. Together with the community, Malaguzzi developed an educational approach that became the basis of what is today known as the Reggio Emilia approach. (Puurula 2013.)

Much like the constructivists, Reggio pedagogy also questions the role of the teacher in the classroom. Children are given freedom, because the child is seen as the center of his or her education. The ideal education simply gives time for the development of children's own ideas and understands that it is a long and slow process. The teacher is considered to be more of a co-learner who listens and respects the child's ideas and gives them an opportunity to grow. The teacher trusts that the child is interested in things that are worth learning. (Wexler, 2004, 13–15.)

In Reggio pedagogy, aesthetics is considered as one of the most important qualities in life, and therefore it is revered in education (Vecchi 2010, 5). The idea of beauty is an all-encompassing element in Reggio schools. Interiors are carefully and thoughtfully designed and the materials in the classroom are arranged and rearranged often to bring out their aesthetic qualities. But more so, aesthetics is seen as a way of being. The aesthetic sense is a natural one and Vecchi (2010) argues that it is a necessary element in developing fragility, emotion, empathy and ability to see relations in seemingly unrelated things. Vecchi (2010, 26) goes as far to say that losing touch with aesthetics leads to an absence of a relationship with the environment, which in turn can lead to injustice of the heart.

In this approach the focus is on encouraging the symbolic representations of children. For Malaguzzi this idea was about fostering the "hundred languages of children". Malaguzzi felt that school should support any expressive method the child wants to use, be it words, movement, music, drawing or building. (Edwards, Gandini & Forman 1998, 7.) He felt that art was a necessary element to support this, and so he introduced ateliers into the classrooms which were organized by a person with a background in the arts (Vecchi 2010, 12). In this sense, Reggio encourages a hands-on approach to learning. Through active participation in learning, the child can build a personal and meaningful relationship with the environment.

2.3 Art and Images in Learning

> *"Qualities I sought in a scientific theory were naturalness, inner perfection and logical simplicity from an aesthetic approach."*
> *– Albert Einstein*

Our educational system is highly focused on teaching children analytical and logical subjects. These subjects are often taught verbally and benefit those with an auditory learning mode who think form trees to forests, or details to wholes. For example, as of 28.6.2012 education

for grades 1–9 is made up of 64 units of language and literature studies, 32 units of mathematics, 31 units of sciences and 12 units of history. In relation, artistic subjects have not gotten enough attention: music consist of 8 units, fine art of 9 units and handicrafts of 11 units. (Valtioneuvoston asetus 28.6.2012.) These subjects teach a different type of thinking mode. An analytical thinking mode maybe good for some things but perhaps it should be evenly balanced with an equal amount of artistic thinking.

The absence of art as a cognitive tool for learning in schools may be explained by the fact that in psychology it has usually been thought that science itself is the only way to produce reliable knowledge. Efland gives three more specific reasons why art has not received proper emphasis in education. First, art is thought of as a "nice" elective option in education, but it is thought of as a subject which plays no serious role in the development of the mind and personality. Secondly, art is seen as a subject for cultivating creative expression without seeing the link that art has to developing cognitive abilities. Third, educators do not have the proper knowledge and skills to develop thinking and knowledge acquisition through the use of art. (Efland 2002, 6–7.)

Efland argues that human intellect was simplified by attempts to create certain laws on human cognition. Logic has made cognition into objectivism, which is a belief that things are as they actually exist in the world and are represented by symbols which are disconnected from the mind that experiences them. He argues that in this way learning becomes very computational and no room is left for imagery in cognition for example, the ability to think metaphorically. (Efland 2002, 5–6.) This is perhaps how Steiner (1996) felt as well, as he suggests that art is a way of educating which connects us to the world. When we reflect on the world through symbols we ourselves have created, we become connected to our surroundings in an individual way. The Reggio Emilio approach supports this view as well by encouraging children to build representations of the environment through an individual language (Edwards et al. 1998).

In my experience, the integration of art into other subjects was very superficial throughout my schooling. For example, drawing might have been integrated into history by asking the students to draw historical figures or maps. These kinds of tasks are mere imitation, and do not really have anything to do with the core of art. The student is not learning history through the method of art because the knowledge of the drawing becomes separate from the information which is learned. The possibilities of the intuitive qualities of art are not being used. It seems that art is integrated into education superficially. In attempting to integrate the visual arts into the curriculum, it

is treated as visual representations. This lacks an understanding of the deeper meaning of art. Integrating visual elements into education to me is not integrating art into education.

2.3.1 Self-constructed Images in Learning

Through the previous educational perspectives I have gained understanding of the value of art in education for its ability to support an individual, subjective experience of our environment. I find it important to examine the way that the use of images supports this view, especially to look more closely at what the significance between self-constructed images versus given images is in learning.

Renowned art educator Viktor Lowenfeld felt that adults should not impose any of their own images on the child because adults do not experience the world in the same way that children do. While he saw imitation as essential to learning he felt that it was only a means for an end. For example, we learn languages through imitating the words we hear. But if our language skills were left at this stage, we would only be able to repeat the words and sentences we hear, without being able to understand their meanings. Children who are forced to imitate become dependent of other people's thoughts and ideas in their own expression. (Lowenfeld 1947, 21.)

Lowenfeld was also concerned about workbooks for children which portray stereotypical images of objects. He felt that these kinds of books deprived children of their sensibility to those objects and of their natural relationship to those representations. Often workbooks and coloring books only require the child to do imitative tasks. (Lowenfeld 1947, 22–25.)

Steiner also believed that when teachers are visualizing things, for example plants, this should not be overdone, so that the students can imagine for themselves with emotion, the connections they have to the plants. He acknowledged that images had the capability of helping the child learn holistically, and that holistic learning was especially important in early education. Nobel has chosen a good quote by Steiner to describe this:

> *"In modern manuals one can read accounts of the most wonderful courses of Nature, such as the presentation of the embryonic life, and this is then taken up in our schools. But one can also become completely desperate over the intellectual chill which meets one, and how everything artistic – and there is nothing purely intellectual in living nature – how this artistic aspect has been deliberately and methodically obliterated here. If one exaggerates this intellectual aspect and is not able to transform the subject-matter into images, then there arises a fine, subtle disarray in the child's*

creative exploration of knowledge." (Rudolf Steiner in Nobel 1991, 243–244.)

I think this is a very important thought to consider. In Finland, mathematics books in elementary schools are highly visual. In the first grade the pages contain almost only images, and are full of colors. Slowly the images fade away and by 7th grade there are only a few left. Although I think that visual elements are very important in learning, it is also important to consider what kind of images are given. Mathematic books in the first grades do allow the children to draw images based on cognitive skills like mental rotation, but no self-reflective creation of images is included, which would support the "creative exploration of knowledge" as Steiner mentions.

Self-constructed images were also studied by Britta Bull and Merlin Wittrock who examined the role of retention among three methods of teaching. They wanted to examine the effects of self-discovered imagery, experimenter-supplied images, and verbal definitions. They taught sixteen different nouns to three different groups of fifth graders. Half of the nouns were ones with high-imagery and the other half were ones of low-imagery. (Bull & Wittrock 1973, 289–293.)

The first group was given only the words and their definitions and was told to learn the meanings of the words by writing them down repeatedly. The second group was given images in addition to the words and definitions and was asked to learn them by writing them down and tracing the image. The last group was given the word and its definition and was told to write the word down and then draw a pictorial representation of the word and its meaning. The results of the study showed that the retention rate for the third group who had to draw their own images was far better than the retention rate for the other two groups. (Bull & Wittrock 1973, 289–293.)

There is extensive evidence from psychology and cognitive sciences in the beneficial use of images in learning and memory, a topic which I will return to. The educational perspective tends to look at the role of images in a more holistic fashion, considering its effect not only to cognitive skills but also to emotional well-being. In this sense, the influence of images can be detrimental if they do not resonate with the viewer. The benefits of images in learning without their harmful effects might best be gained by allowing the learner to construct these images.

2.4 Intuition in Learning

"Acquired knowledge is only the musical instrument for which intuition builds the hidden melodies for." – Andrew Jackson Davis

Intuition is a relatively undefined term, mostly because it is very difficult to differentiate the several processes that are happening in our minds

and brains at once and because the way people experience intuition can be highly personal. One definition of intuition is "experiencing knowledge without knowing how one knows". (Dunderfelt 2008, 30.) Intuition is not the same thing as emotion. Emotion is feeling, while intuition is perception. Intuition is usually a quick flash while emotions linger in the mind for a longer period of time. Intuition is direct, clear and freeing in its nature while emotions are unclear and oppressive. (Dunderfelt 2008, 57.) There are also differences between intuition and creativity. Creativity is a complex, often a long process. Intuition might be the short glimpse which sets off creativity, or the "creative spark". (Dunderfelt 2008, 115.)

Intuition is an integral part of our thinking. Without intuition we cannot understand the new information which the rational mind analyzes. Intuition is a trait which can be developed and this development can bring new kind of knowledge into decision-making. (Raami & Mielonen 2011.) Yet, Harvey (in Raami & Mielonen 2011) suggests that the development of intuition is not taken into consideration when designing curriculums, even though it's importance is commonly acknowledged. Raami & Mielonen (2012) pose that intuition should be integrated into rational thinking to receive the full benefits of its use.

Intuition is a channel to the unconscious. The unconscious mind holds most of what we have learned and experienced throughout our lifetime. Intuition researcher Frances Vaughnan claims that our unconscious mind also holds a limitless supply of collective, universal knowledge. This might sound strange, but intuition is a concept which cannot fully be understood without the concept of spirituality. (Dunderfelt 2008, 62.)

American psychologist and philosopher William James believed that there are in fact many forms of consciousness in us and that those forms of consciousness could be attained through symbolic sensory elements.

> *"Our normal waking consciousness, rational consciousness as we call it, is but one special type of consciousness. Whilst all about it, parted from it by the filmiest of screens, there lie potential forms of consciousness entirely different." (James 1902, 497.)*

Intuition reveals itself in a variety of contexts in our lives, but art can be an especially intuitive process in its spontaneous, abstract or irrational nature. When painting, I find myself working largely through intuitive decisions, for instance, when choosing a certain color or deciding on an arrangement for the composition. Often I find that if I make sketches of a painting they are better than the actual work. I think that this is because I make sketches more intuitively and

when I start to work on the "final" piece my work becomes too conscious and too rigid. Through this process I have learned to appreciate and trust the intuitive instincts that I might have because they often lead to better results.

I also feel that when I make something intuitively it becomes a reflection of myself. When I started my studies at Aalto University, it was difficult to get used to receiving critique for my artwork, although it has never bothered me too much to receive a bad grade on a test or an essay. Artwork is more personal in this sense. This is why I believe that what results from the process of making art is a glimpse into the unconscious mind or to an "inner essence". Intuition researcher Jeffrey Mishlove describes inner essence as "The source of being within each of us and within the universe itself. It is also the origin of intuitive guidance and of self-esteem." (Mishlove 2013.)

As children we all knew this essence in ourselves. This can be seen in the way that children naturally express themselves through play, music, drawing and dancing even before they learn to speak, read or write. Society does not encourage children to develop this essence, and so most people slowly lose a true connection with it. Lowenfeld describes this well in the context of art education:

> *"If children developed without any interference from the outside world, no special stimulation for their creative work would be necessary. Every child would use his deeply rooted creative impulse without inhibition, confident in his own kind of expression." (Lowenfeld 1947, 20.)*

While the effects of the deprivation of "creative impulses" can most directly be seen in the arts, it is also harmful for cognitive processes. Scientists especially have been known to have a developed intuitive sense. Therefore, integrating the arts into learning might best be done by developing the use of intuition. Constructing colors and forms out of numbers is at its core an intuitive process due to its spontaneous nature.

2.4.1 Color, Form, and Semiotic Meaning

> *"The possibilities of the influence of art are not exerted to their utmost." – Wassily Kandinsky*

To me art is about intuition working to reveal itself in order to resonate with the soul ("inner being" or "consciousness") of the maker, creating as a result, an aesthetic experience. I also feel that images, or any form of art, are a direct path to our inner being and this inner being is the source of intuition.

Many artists, especially those who worked at the turn of the 19th and 20th century had similar thoughts. They believed art to be a highly spiritual process. Many of these artists believed that color and form were directly connected to the

soul. The movement especially concerned with these thoughts was the abstract art movement originating from the symbolist ideas, especially those of Wassily Kandinsky.

I find it important to examine the subject through the viewpoint of someone who has been revered for his work in art. I believe that integrating the elements of color and form which reflect the subjectivity of the individual we gain a more natural connection to knowledge. Kandinsky related the attainment of knowledge directly to the soul, and that this knowledge could be attained through intuitive tasks (Kandinsky 1910).

Kandinsky talks about the "impressions we receive" (I have understood this to mean visual imagery). These impressions consist of three elements: color, form and the relationship between color and form (the relationship meaning the "object" itself). These elements hold in them a semiotic meaning which the user has intuitively built. When a person chooses an object it is chosen by a "corresponding vibration in the human soul" thus always being an individual representation. This vibration was capable of bringing about new knowledge (Kandinsky 1910.)

Kandinsky believed that colors have clear effects, like lime yellow which screams for attention, but also more subtle effects, psychic effects which are deeply connected to the soul (Kandinsky 1910).

> *"It is evident that color harmony must rest only on a corresponding vibration in the human soul and this is one of the guiding principles of the inner need." (Kandinsky 1910.)*

I feel that these thoughts are very similar to those that Steiner, Malaguzzi and Lowenfeld have talked about in the context of education. They all speak of the importance of individuality in learning. Therefore, these thoughts integrate well into education. By tapping into these vibrations in ourselves we can attain knowledge through a personal method of form or color mediations (a topic I will return to later) which matches imagery with numbers in a way where the two resonate at the same level to us.

2.5 Visual Cognition

Visual thinking seems to be a primitive, yet powerful tool for us. We were thinking visually before we ever learned to speak. For example, when a baby can remember that a toy is hidden inside her blanket she is using visual thinking. Humans were communicating with paintings before written language was formed. Even writers who use words as their main tool often paint pictures with these words, so that the readers can imagine a picture of the situation in their heads. (Reed 2010, 1–2.) Visual thinking seems quite

natural for us, yet language is emphasized in our society and especially education.

Visual thinking does not act as a tool for just the artist or designer. Words like "insight" and "imagination" reflect the role of visual thinking, and are elements of discovery in arts and sciences. Visual thinking is also an important way of thinking for scientists. Einstein is famous for his visual thinking which he talks about in a letter to the mathematician Jacques Haramard:

> *"The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The physical entities which seem to serve as elements in thought are certain signs and more-or-less clear images which can be `voluntarily' reproduced and combined. The above-mentioned elements are, in my case, of visual and some of muscular type." (Albert Einstein in Kriz, 2008.)*

2.5.1 Visual Imagery in Learning

The Stanford encyclopedia of Philosophy defines mental imagery as "quasi-perceptual conscious experience per se". This means it has some of the properties of the original perception and this can appear in the mind in association to any of the senses. Visual imagery is therefore: "hypothetical quasi-pictorial representations in the mind and/or brain" meaning they have the properties of a visual representation. (Thomas 2010.)

Visual imagery has been found to be effective in learning and this is greatly due to the work of Allan Paivio in the 1960's. According to Paivio, the two main modes in which the brain processes information are verbal and imaginal. Imagery is a way to transfer verbal information into a concrete imaginal mode. According to Paivio's dual-coding theory, imagery is of key importance in the retention of information. (Broudy 1987.) This is because an image can act as a second memory code to support a verbal memory code. If a person had to recall the idea of an apple that person might think of the word apple or the image of an apple. The image and the word are independent codes, so the person is able to recall the idea of the apple, with either one of the codes. (Reed 2010, 48–49.)

Egan believes that mental imagery should play a big role in teaching and learning. Encouraging children to develop their own mental images is increasingly important in Western societies which are filled with images. Mental images are universal among oral cultures and they serves as an emotionally important cognitive tool. (Egan 2005, 4.)

> *"Rarely in my experience and from my reading of teacher-education methods texts, do we reflect on the vivid images that might be evoked by the content we wish to teach. Given the universality of image-generation in all oral cultures, it would be prudent to reflect on ways*

to use this cognitive tool in teaching." (Eagan 2005, 27.)

Previous research by V.A. Kruteskii, suggests that visual representations are important in mathematics, because they give the learner an intuitive understanding of the subject and that spatial abilities correlate with mathematical achievement (Hegarty&Krozhenikov 1999). However N.C. Presmeg (1986) shows that not all kinds of visual images are useful, and some can even have negative effects.

A study done by V.A. Kruteskii, as described by Hegarty and Krozhenikov, found that there are three types of mathematics learners: visualizers, verbalizers and mixers. Visualizers tend to use mental imagery when solving problems, verbalizers use a verbal, more logical method and mixers have no preference either way. (Hegarty&Krozhenikov 1999.)

Presmeg (1986) found that when looking at a group of high school students, they tend to use five types of imagery: a) concrete pictorial imagery which refers to pictures in the mind; (b) pattern imagery which refers to relationships in a visual-spatial set-up; (c) kinesthetic imagery which involves physical hand movements and gestures; (d) dynamic imagery, which involves dynamic transformations of geometric figures; and (e) memory of formulas where visualizers imagine a formula as it was represented on a textbook, notebook or on the blackboard. Presmeg found that concrete pictorial imagery may have a negative effect on learning, because this may lead the learner to think about irrelevant details, and as a result get distracted from the main elements of the problem. The most essential type of imagery was found to be pattern imagery, which deals with relationships. (Presmeg 1986.)

Hegarty and Krozhenikov comment the studies and suggest that the division of learners into verbal and visual, as described by Kruteskii, are obsolete and a more important aspect affecting differences in mathematics learning is whether individuals use pictorial (detailed and concrete visual representations) or schematic imagery (spatial transformations and relationship). Here they came to similar conclusions with Presmeg, that the use of schematic imagery has positive effects on problem solving, and the use of pictorial imagery has negative effects. Therefore, they propose that schools should encourage students to construct imagery on the relationships of the problem, not to visualize concrete details. This emits irrelevant details. (Hegarty&Krozhenikov 1999.)

Although the study by Presmeg was done on high school students, it still reflects the attitudes, or cognitive processes acquired at a younger age. The study shows that there is a need to examine a wider array of thinking skills beyond those traditionally considered important in

mathematics. Visual thinking skills have an association with mathematical knowledge, and so it seems that these two things would work well together in teaching The case also shows that not all students in the study were producing their own visual images (visual representations were not given by the organizers of the study). They were producing them concretely, which was found to be negative.

Concluding the section, it has been found that many scientists and mathematicians have a high ability to think in visual images (West 2009).

> *"... in disciplines such as physics and mathematics, really original solutions to novel problems often (though not always) seem to come from those who work in the more fluid and malleable medium of images." (West 2009, 252.)*

It is this "fluid and malleable" quality of images that I think is very important. If we don't cherish this quality then our world becomes too standardized and our minds are locked into a box that no one has the key to. The development of personal images allows the person to move deeper inside, finding in the images the true essence of themselves. But as knowledge is constructed through images, they can also be reflected further outside of oneself. Mental images allow the mind to wonder and explore. They become constructed into any direction desired. They don't have outlines like letters or numbers.

2.5.2 Color Mediation

> *"What would be truly surprising would be to find that... that sound and color were unsuitable for the translation of ideas, seeing that things have always found their expression through a system of reciprocal analogy..." – Baudelaire*

Otto et al. (1998) describe a study done in 1962 by J.K. Jones who determined that children learned to match letters and words better if the task was given in color, instead of black and white. Jones gave children tasks where they had to match English reversal letters (p, q, u, n, d, b) in one part, and six different words turned into unfamiliar script in another part. Both parts were completed with color cues and without them (as black and white). Not only did the children succeed in the colored version three times as well as in the black and white version, but they also preferred the colored version over the black and white. This study shows that the use of color in learning can act not only as a cognitive aid, but as a motivational aid as well. (Otto et al. 1968.)

A study was also done to find out if color mediation could help students with learning disabilities learn number identification and simple, one-digit multiplication (Van Houten

& Rolider 1990). In the first experiment, three students in ages 6–8 were shown cue cards with numbers written on them in black. They were asked to identify the number that was shown to them. The students identified the numbers they knew before the study, but for those that they did not know previously, the cue cards did not help them identify the numbers, even though they were corrected each time they gave a wrong answer. After this, the cue cards were done so that each number was represented in a different color. The students were asked to identify the numbers with their colors, for example a "green three", and if they did not do so, they were corrected accordingly. When they were able to identify the numbers correctly, the color mediation was dropped. The students were now able to identify the numbers correctly even when they were printed in black. They were able to answer 100% of the numbers given correctly. (Van Houten & Rolider 1990.)

Another experiment was then done to see if student could learn simple multiplications in the same way. Two students, one nine-year-old and one eleven-year-old were both taught six single-digit multiplication problems that they did not know previously. They were first shown the answers to the problems in colors and were asked to identify the color with its number, for example "red 81". They were then asked to associate the numbers with the colors without the cards. After this, cards with the problems on them were shown in the corresponding color to the answer. They were then asked to identify what color the problem was, for example "what color is 9x9?" and to answer with both the color and number together, for example "red 81". The color prompts were slowly discontinued in the process and they were then able to answer the problems correctly with the color and number, even when presented in black. Before the procedure the eleven-year.old was able to answer the problems correctly 25.5% of the time, while the nine-year-old averaged 10.6%. After the experiment both student were able to answer the problems with 100% accuracy. (Van Houten & Rolider 1990.)

In these experiments, the colors were chosen by the instructor, not the student. I think that if children were given the opportunity to match numbers with personal colors at an early age, this kind of association would come naturally later on when having to apply them in problem solving. This will be of use for the student similar to those in the experiment, who clearly show that they are able to learn very well, as long as they are given an opportunity to work with a medium that is natural for them, in this case color. It also shows the importance of having different methods of learning and knowing, instead of labeling students as having a learning disability, a label they will carry with them for the rest of their life

The last two experiments also show the power of imagination. The students could identify the

correct numbers and answers to the problems even when the color mediation was discontinued. Therefore, it seems that if instructed properly, students perhaps do not need fancy tools and elaborate material to learn, as they can imagine and visualize the problems in their heads. Developing this ability in children could be very beneficial.

2.6 Synesthesia

Synesthesia is a condition where different senses become intermingled in a way that one of the sense modalities immediately arouses another sense modality. As a result the person affected might hear colors or smell sounds. Synesthesia can occur between any two or more senses and it is involuntary, so it happens without any effort from the synesthete. (Van Campen 2008.)

Grapheme-color synesthesia is a form of synesthesia in which the person affected is able to see numbers in colors (figure 3). The colors in which the numbers are perceived are personal, as even synesthetes in the same family will not see the same number in the same color. In addition, these color associations are intuitive, as the synesthete cannot recall why the numbers are seen in their specific colors. (Van Campen 2008, 66.)

Figure 3: a synesthete's colored numbers.

2.6.1 The Art of Numbers

Daniel Tammet is a savant and synesthete, who had severe brain damage to his left hemisphere as a child. As a result, he became able to learn languages exceptionally fast and count complicated math problems in his head in a matter of seconds. (Miettinen 2010.)

Tammet has a highly developed sense of numbers and the way he understands them is very artistic. Tammet holds the European record for reciting the most decimal places of pi (Tammet 2009.

59). What is more impressive to me is the way he describes this process:

> *"…my mind perceives numbers as complex, multidimensional, colored and textured shapes. Using these shapes I was able to visualize and remember the digits of pi in my mind's eye as a rolling numerical panorama, the beauty of which both fascinated and enchanted me. One of my fondest memories from the pi event in Oxford is the profound sense of joy I felt at that visual experience of the numbers' beauty. The public recitation of number after number after number developed into a kind of meditation for me, as I grew more and more wrapped up in their flow. Although the digits of pi are, mathematically speaking, strictly random, my internal representation of them was anything but – filled with rhythmic strokes and structures of light, color and personality (figure 4). From this random assembly of digits I was able to compose something like a visual song that meandered through every contour of my mind, through which I was able to hear the music of the numbers…" (Tammet 2009, 59–60.)*

The way Tammet describes this process is certainly quite different from the way that numbers are currently being taught in schools, and nevertheless he is successful in their use. Daniel shows us that our view of what "normal" is, is limiting the potential of humans. If children do not learn through the traditional teaching methods they are labeled as autistic, dyslexic, and so on. This only concentrates on what these children lack compared to the majority of the population. But I believe that a lack of something most times means an advantage in something else. Education should nurture the natural abilities and tendencies that people have, because this way learning will feel more effortless and motivating, and every child can feel that they are talented.

Figure 4: Daniel Tammet's visual landscape of pi.

Many synesthetes, like Tammet for example, use this skill to memorize series of numbers, and in this case their synesthesia seems to be an advantage for them. Nevertheless, according to Van Campen, grapheme-color synesthesia can either be an advantage or disturbance when

doing arithmetic. Van Campen has interviewed many synesthetes. I have taken from his book two quotes which I think well describe this phenomenon: the first from Katinka Regtien for whom the colors of her numbers serve as an aid to do calculations with, and the second from Wendy Spijkers for whom her colors interfere with her counting. (Van Campen 2008, 71.)

> *"When I add fifteen and eighty-three, I see mentally first a cream white line (the color of ten) and a green line (the color of eighty). In that first moment I already see that the result will be in somewhere around the brown line, which is the color of ninety. So I start the arithmetic with cream white, green and brown lines, corresponding to ten, eighty, and ninety. Then I zoom in to the place where the smaller numbers are, and the blue five of the fifteen gets more significance than the cream white one (which stands for ten) , although the number fifteen is normally more white than blue. The same happens with the number eighty-three. The three is kicked three steps on top of the five and lands on the place of the number eight. And so the outcome is ninety-eight. (Regtien in Van Campen 2008, 71.)*

> *"When I have to multiply numbers, say, three times three – that is yellow times yellow – which becomes a pink-red nine, I first have to let that sink in before I can proceed. If I go too fast in doing sums. I lose the colors and the numbers and have to start again." (Spijkers in Van Campen 2008, 71.)*

I hypothesize that whether synesthetes are able to use their imagery to an advantage is dependent on how they build relationships through these images. The study done by Presteg (1986) that was mentioned earlier regarding pictorial and schematic imagery might give clues into this issue. If the synesthete puts too much attention into the pictorial qualities of the imagery then this will distract from the main element, in this case counting. But if the synesthete is able to balance the pictorial nature of the images with their schematic nature, then this might ease with solving the problem.

Van Campen suggests that synesthetes use the same logic to calculate as nonsynesthetes but that they simply use more mental aids (Van Campen 2008, 71). Some are able to use them to an advantage, and for some they are a disturbance. I am not concerned with how to produce synesthesia, but how to induce the kinds of mental aids, in a visual format, which will be an advantage in counting. In these examples it is also important to note, that people have very different learning styles, and so a student should be taken as an individual, and seen to what extent these kinds of aids will help this individual, so as not to confuse him or her with colors and shapes.

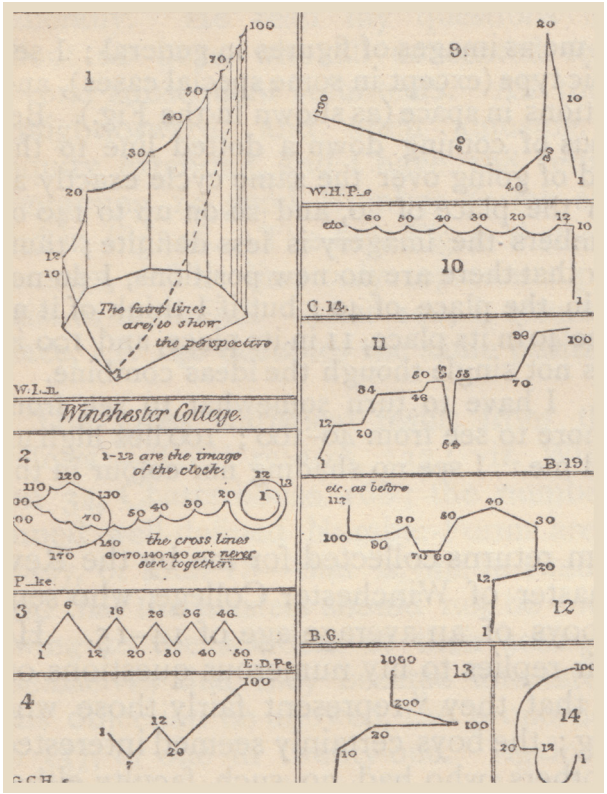


Figure 5: Galton gathered drawings of number-forms from his subjects.

2.6.2 Number Forms

In addition to seeing numbers in colors many people, not only synesthetes, also perceive numbers in space. Here, numbers are arranged in elaborate ways, not just from right to left. The numbers have specific locations and sizes in relation to the other numbers. (Van Campen 2008, 78–82.)

Number forms and colored numbers were already studied in 1983 by scientist Francis Galton. Galton noted that there are people for whom numbers hold specific locations (figure 5) in space and that these arrangements are often unconventional (Galton 1919, 79). He found that about 1 in 30 men and 1 in 15 female experience these number-forms (Galton 1919, 82). Van Campen (2008, 82) states that according to current research the number is 1 in 10 among the whole population.

None of the people whom Galton studied could recollect the origin of the phenomenon, and all said that they have had it as long as they can remember (Galton 1919, 86).

Van Campen, who looked at individual examples of synesthesia, quotes Rosanne Van Klaverten who describes her number-form (figure 6 on the next page) and the way she is able to benefit from its use in arithmetic:

"When I learned the numbers one to ten, I threaded them on my personal wire. The numbers eleven and twelve got their place at the right-hand side where they filled the space with other tens that I already knew. Now, all numbers have had their own place in the space for years, and I can zoom into or out of the mental image. The number-form is always present when I am doing sums. When I add 239 to 603, I immediately see their positions for my mind's eye. Numbers such as 600 lie much higher and more to the left than numbers in the beginning of 200. First, I jump in my scheme to the 800, which lies higher and more to the right from where I start, and then I zoom into the image until I reach 842. That might sound very laborious and time-consuming to others. But for me it is not. It is an automatic process and it helps me." (Van Klaverten in Van Campen 2008, 82.)

2.6.3 Possibilities of Synesthesia

As Tammet was one of my inspirations on this project, I am interested in the possibilities of inducing the kinds of landscapes that Tammet saw in his head, through education. The idea is not to try to induce synesthesia, but I think it's important to think about if it might be an ability that we possess and were born with but are not conscious of. Perhaps we are not able to use it to our advantage, because we have already learned other ways to perceive the world.

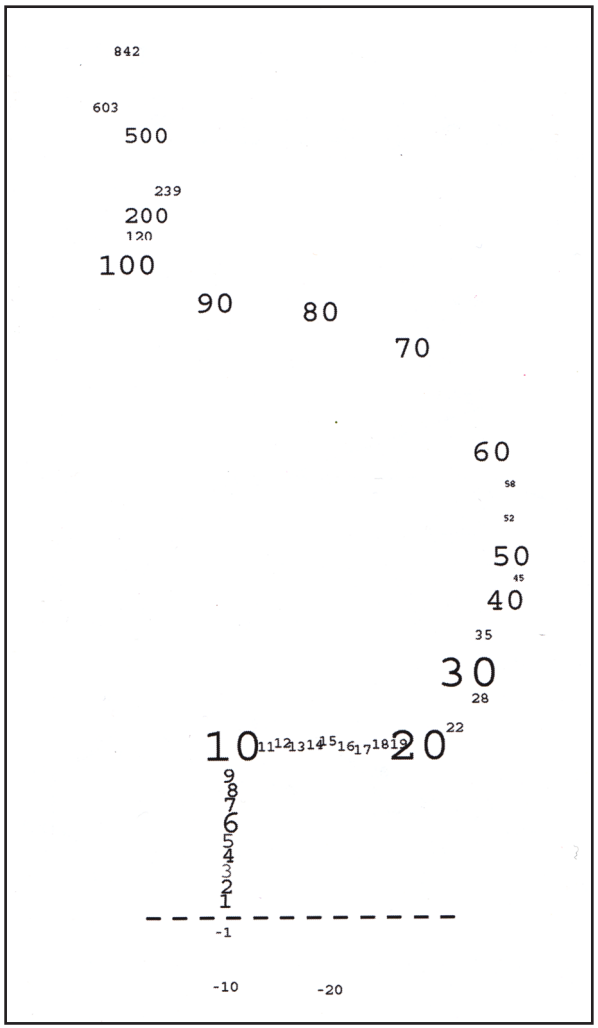


Figure 6: Van Klaverten's number-form.

There are two dominant theories about the nature of synesthesia: hyperconnectivity-hypothesis and disconnectivity-inhibition hypothesis. The first argues that the cross-modal interaction present in synesthesia is due to a difference in brain structure, where greater neural connections appear in the affected areas. Supporting this evidence are findings that synesthesia seems to run in families. It also seems to be more common in women (6:1) which would indicate its presence among the x-chromosome. The second argues that there are no such structural differences, and that the abnormal experience is due to the inhibition or disregard of signals within or between brain areas. (Cohen et al. 2009.)

The disconnectivity-inhibiton theory suggests that it would be possible for anyone to have synesthesia. There are a few cases that would support this idea. One study suggests that we all are synesthetes as babies and that this skill quiets down in life because it is not trained. It has also been found that children are more likely to have synesthesia than adults are. (Teng, 2013.)

If the disconnectivity-inhibition hypothesis is found to be true, it might then be possible to induce synesthesic qualities to aid learning by consciously training them. This is interesting because it might then be possible to adapt this technique of visual and perhaps emotional association to learning. I see that these theories are not necessarily independent of each other. If we notice that certain abilities of our brain are being disregarded, and we learn to train these abilities, then it is clear that structural brain differences would occur.

Synesthesia has also been induced by hypnosis and drugs. The anthropologist Reichel-Dolmatoff (1970) studied native tribes in the Amazon. Many tribes in the region used a hallucinogenic drug which was used in rituals. To the Tukano Indians, the drug enabled the person to return to the origin of the universe and to see its creation. The person "dies" and then revives with great clarity and wisdom. The antrhropologist drank the drug, and reported seeing vivid visual imagery. (Reichel-Dolmatoff 1970.)

Many of the native tribes seem to have a synesthetic way of perceiving things that is culturally universal (Classen 1990). Reichel-Dolmatoff (1970) describes the way that the Desana Indians perceive a song that is played on the flute by prebuscent boys:

> *"The odor of the tune is said to be male, the color is red, and the temperature is hot; the tune evokes youthful happiness and the taste of a fleshy fruit of a certain tree. The vibrations carry an erotic message to a particular girl." (Reichel-Dolmatoff 1970.)*

I have taken this example to give light to the way we use our senses. Perhaps in the Western world we have taken for granted the potential that lie within us in perceiving the world. Somewhere along our evolution it became inefficient to our development to have this kind of sensory intermingling. But now that we don't have to run from predators anymore, I think we should explore all these "primitive"abilities in us. We might find that our perception of the world is a very narrow one.

2.6.4 Synesthesia and Memory

As a major element in learning, memory should be observed in relation to synesthesia. The following studies show that synesthesia improves memory and that people with superior memory do not perform well because of structural brain differences but because of training, such as adopting a visual memory technique. So even people without synesthesia, might adapt some of the visual techniques used by synesthesia for improved memory.

A test done by Yaro and Ward (2007) on 46 synasthetes who were asked to rate whether they believed their memory was a) better than the average, b) like the average or c) worse than the average. Of the subjects 70% believed that their memory was better than average. In another experiment 16 synesthetes were tested against 16 controls. Both groups were asked to complete a set of tests to measure their auditory-verbal recall, color and digit recall as well as color perception. It was found that synesthetes had better memory when recalling information which induced their synesthesia but that this advantage was not limited to this synesthesia-inducing material. In addition, synesthetes who have exceptional memory, have it because of training. (Yaro & Ward 2007.)

The subject was also studied by Maguire et al. (2003) who used brain imaging to find whether this superior memory was due to structural brain differences. Ten people with superior memory (not necessarily synesthetes), and ten control subjects were asked to learn different sequences of material presented. The results indicate that there was no structural brain difference, but that superior memorizers had adapted a spatial learning strategy which involved the use of the hippocampus. Of the superior memorizers, 90% used the "method of loci" an ancient visualizing technique. Those with superior memory did not perform differently in visual memory and this may be because superior memorizers usually do not actively train this kind of memory. Instead, when tested on numbers, all of the superior memorizers associated the numbers with images of people, animals and objects, while none of the controls did the same. (Maguire et al. 2003.)

The results of the study are interesting but also seem to contradict the results of Presmeg

(1986) who found that pictorial representations were not as beneficial to learning as schematic representations. In the previous study, the synesthetes reported using images of people, animals and objects, which sound more pictorial than schematic. Of course more information on the nature of these images would be needed to make any conclusions, but from these studies I would hypothesize that maybe concrete images are good for memorizing, and abstract ideas are good for understanding and manipulating information. The suggestion that synesthetes have better memory is possibly also related to Paivio's dual-coding theory.

2.7 Further Thoughts

Learning to experience the world aesthetically gives us the ability to experience the world holistically through many fine-tuned senses. When children then learn other subjects, in my example math, they are able to perceive in it a world of qualities not instantly apparent. Children will start to produce aesthetic experiences from all knowledge. Maybe it is the development of aesthetic experience that starts to produce aesthetic qualities out of any phenomenon in our environment: numbers, letters, months or days.

In this way, these elements start to build on top of them different sensory qualities: colors, tastes, feelings or maybe even personalities. The person might be able to use these to an advantage in learning, because he is more connected to that knowledge. Through art, we start to have a truly personal connection to our environment; maybe you could call it a spiritual connection like Steiner or Kandinsky might have done, or just say that it is a highly individual way of being. I will also hypothesize that by having this personal connection to our environment, we also start to think in a more independent way, a way which produces original thoughts. We become individuals who are more aware of themselves, and therefore will not be so blindly affected by advertising or political bias.

We live in a society where we are bombarded with outside influences. Society is also becoming more global, and as a result these outside influences are becoming more and more alike in all parts of the world. The same television shows and movies can be seen around the globe, the same advertisements of multinational corporations flash in streets, magazines, and television. The internet is certainly not slowing down this trend. If society does not start educating children to develop a rich inner life, these outside influences will take over a powerful part of people's thinking and feeling. Worst of all, people can then be guided by these outside influences very easily: to buy the things they see in ads, to act like the people they see in movies, etc. These people will lose touch of their own purpose in life, and this is not a good basis for a happy, balanced and emotionally healthy life. With a rich inner life,

one doesn't need so many materialistic goods. After all, we are what we think and how we feel, not what we own.

By giving children a teaching approach which highlights the individuality of that child we are giving them an example, that each person is significant in his or her unique way, as opposed to forcing children to complete the same activities in the same way and then comparing them to each other like a competition. How can children be expected to be open and tolerant to others when we are teaching them to compete against each other? Schools are failing at their task, if they are only giving children the tools to be efficient cognitively while harming their spiritual and emotional growth.

3. Making of the Children's Book

My production is a children's story- and activity book (figure 7). Its' purpose is to develop the reader's intuition and to teach number-sense. The book tells a story about a cat and a girl. The girl is having trouble identifying numbers and so the cat teaches them to her through different activities. The reader/listener can complete the activities as the story goes along. The activities can all be completed through creative and spontaneous drawing. At the end of the book, the reader has completed a visual map of his/her personal number images. In this section, I will document the process of designing the children's book. More on the decisions that were made in the design process which were influenced by the theoretical framework can be seen in the section "Integrating the Theory into the Production".

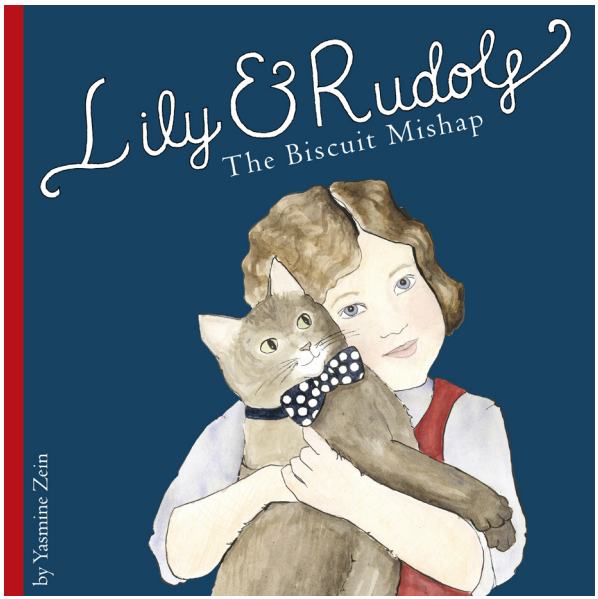


Figure 7: The cover of the children's book.

3.1 Audience

My book can be used to develop number-sense and so it is mainly targeted at kids who are just starting to learn their numbers. When testing the book, it was found that it was especially suitable for 5- and 6-year-olds. Alternatively it can be used by those who are further ahead in math but are having trouble learning and seem to just need a different approach. Older students can benefit from the book, because visualizing numbers gives another way of communicating to parents and teachers the troubles they might be facing with math. There is no age limit for using the book though, because it also develops intuition, which might be especially beneficial to adults. One might also want to develop number-sense through this different approach at any age.

3.2 Characters

When starting to brainstorm ideas for the book, I found it difficult to start developing a story around my theory. So, I started imagining what the characters would be like, with the hope that I could then build a story around those characters. This turned out to be helpful. The first decision I made regarding to this was that one of the main characters would be a cat. Since I have had a cat as a pet most of my life, I know the behavior of these creatures quite well, and so I find it easy to write about. The other main character that I chose is a little girl. Of course knowing what it is like to be a little girl probably affected this decision but mostly it was an intuitive choice. I also like drawing people and animals. Making sketches of the characters worked as an meditative process for me. While I painted I started imagining the kinds of situations they would be in and this brought ideas for developing the story.

3.3 Visual Style and Illustrations

Once I had decided on the characters I started constructing the idea for the book through imagining what kind of a visual look the book would have. I have always liked old children's book illustrations so I wanted to take some influences from them. I collected about 50 different illustrations that I liked, a collection of which is seen on the next page (figure 8). Most of my searches were targeted to find either a variety of art specifically of a cat and a girl, or vintage illustrations from children's books with any subjects. I tried to select images very intuitively without any rational thought. If the image sparked any interest I chose it before I had time to think about it.

Figure 8: Illustrations which inspired the visual style of the book.


They rode their old donkey
They all wen
The HOLE Book
OPEN THE BOOK AND FOLLOW THE HOLE
PETER NEWELL
FUNNY BUNNY
McCALL'S
MAGAZINE
AUGUST 10¢
ROBERT W. CHAMBERS

Figure 9: Some of the first sketches I made from the three visual elements.

From there, I started to observe the kinds of elements that attracted me to the images. The most noticeable ones were:

1) Soft and delicate pastel colors

2) Backgrounds painted with bright even colors

3) Stark contrasts which are strengthened by the use of pure black and white

From these three visual elements I started my first sketches of my characters. In these sketches I was not yet getting too concerned of their relation to the text, rather I wanted to develop the overall visual style.

In the sketches in figure 9 I tried to play with having contrasts in value within the subject (right) as opposed to having the contrast between the subject and background (left). I preferred the one on the left, but I felt that the overall appearance of both was too dark and messy. I wanted to make them look fresher.

In the next sketches (figure 10), I tried to leave more white in the images and use a yellow background color to give more brightness. Still, the subjects themselves did not work so well anymore. I was using a lighter tone (gray instead of black) for the dark areas which was not successful. There was also too much of the gray and it was too still.

Figure 10: Developing the illustrations into a brighter style.

In the next stage, I went back to using black instead of gray to highlight the dark areas (figure 11). Overall, the style was more what I was looking for but the colors on the girl were too light, and I felt the background still did not look right. Here, the top of the image looks too heavy and unrelated to the style of the rest of the image. Although an image can be interesting when there is something unrelated and odd, I just didn't feel that it worked here.

The sketch in figure 12 is already closer to style that I'm looking for. Here I tried to concentrate on just the subject without the background colors, and I am much happier with how the image looks without the backgrounds. Although it was much more simplified than what I had originally thought, it ended up marking the visual identity of my book.

Figure 11 (top): Attempting to bring more contrast along with the brightness.

Figure 12 (bottom): Finding the visual style.

From there, I started developing the story for the book and thinking about the what kind of illustrations would go along with the story.

In figure 13 are sketches leading to the final illustrations (figure 14 and 15 on the next page).

Figure 13: Sketches leading to the final illustrations.

Figure 14: Final illustrations.

Figure 15: Final illustrations.

3.4 Story and Activities

While I was working on the characters and their visual style, I was simultaneously thinking about what kind of a story I wanted to build around them and how the theory would integrate into the story. The development of the story and the activities went hand in hand.

I decided to build my story around a very basic plot with only the two characters mentioned earlier: the cat and the girl. The reason for this was that I needed to keep my story short, since I wanted small children to be able to use the book. The book needed to tie together quite a few activities with the narrative, so it was important that the narrative itself would not require too much explaining.

It was also important for me that the tasks are introduced through a concrete example, since the idea behind them is a bit abstract. I also wanted the task to resolve a problem, to indicate that there is a real motivation as to why these things should be learned. It was important to have a balance of the narrative and the tasks. I tried to make sure that there were some pages in between the tasks where the reader could simply enjoy the story and look at the pictures.

I developed 5 activities around the story which I will now describe. More on the design of these activities in relation to the theoretical findings can be seen in the section "Integrating the Theory into the Production".

1. Coloring the bow (page 4)

In this task, the child is asked to color Rudolf's bow with the colors and shapes that he/she associates with Tuesday. The purpose of the activity is to prepare for the next task. In the next task, the child is asked to draw personal visual mental representations for the numbers from 0–10. This is quite an abstract task, so the bow activity acts as a mental step towards it.

2. Drawing the numbers 0–10 (pages 6–7)

As I said earlier, in this task, the child draws personal visual mental representations for the numbers from 0–10. The object is to encourage children to give a visual association to a number which will help them to remember the number in the future. There were initially 15 (11 to be used and 4 extra if needed) identical square-shaped stickers for activity 2 and 5. There were 6 stickers on one page arranged in a 3x2 shape and 9 stickers on the next page arranged in a 3x3 shape. I later changed these stickers due to problems that arose during the testing.

3. Coloring the ingredients (pages 10–11)

In this activity the child is asked to look at a recipe, and the pictures of the ingredients needed for it. There are 10 of each ingredient, and the child is

asked to color from them, the amount needed for the recipe. The purpose is to apply the previous number task into an everyday activity. The child is encouraged to use the same colors and shapes in this activity as in the last one. In this case, the child can see the visual representations in concrete amounts. For example, if a child drew a red circle for the number 4 in the previous task, and now colored 4 fish with red, the child might associate red with the number four as well as the quantity of 4.

4. Drawing a pattern of the number sequence (page 13)

Here, the child is guided into visualizing a phone number by thinking about the pattern it makes on the keypad. Its purpose is to prepare for the next task, where the child has to draw his own mental image of the way that the numbers from 1–10 appear in his mind. The phone activity is a more familiar example of the number-form activity.

5. Making a visual map of the numbers 0–10 (pages 16–17)

As mentioned earlier, in this task the child is asked to draw his own mental image of the way that the numbers from 1–10 appear in his mind. This is the last task, and it attempts to give the child a more holistic insight into his personal visual images relating to the numbers. Hopefully, this becomes a "map" that the child can use in the future as well. In addition to this, when the child has visualized his/her way of thinking about numbers, those teaching the child, might be able to realize the child's way of thinking and as a result understand when and why the child is failing to understand a problem.

Examples (page 18)

I decided to include examples of patterns that can be used as an aid for this activity. Although the phone activity on page 13 already gives some clue into this task, it might still be quite difficult for children to understand, because it is such an abstract task. This was not an easy choice, because I also felt that examples might give a biased starting point for the child. They might start to think about what kind of an image they are expected to make, and I wanted rather to encourage the children to create the pattern in a way that is unique to them.

I managed to compromise the situation by asking my friends and family to do this activity for me. From those results I then chose four drawings that I felt varied from each other the most and used them as examples. If I had made the examples myself I think that the result would have been a very biased way of representing the numbers because I can only think about the activity in my own limited way. By asking other people to do them, I received representations of different ways of thinking about the problem.

3.5 Layout and Printing

The layout of the book (figure 16) was of course simultaneously in my mind while writing the story and making the illustrations. I had already decided on the alignment of the text on the pages when I designed the illustrations. My husband then completed the technical part of the layout.

I printed the books at Books on Demand, (http://www.bod.fi) a German publishing company. I decided on a square layout because I find it more visually pleasing than the standard A4 or A5 format. Also, I think there is more freedom in a squared page for the illustrations, because the shape doesn't force the images into vertical or horizontal format. At this company, I was able to get the book in 17cm x 17cm size. Ideally, the book would have been a little bit bigger so that there would have been more space to draw and I could have made the illustrations larger, but this size was suitable as well.

As paper, the company had two to select from: a thinner matte paper and a stronger semi-glossy paper. I ordered samples of both and chose the stronger one because it had the appearance of better quality. I was first hesitant, that because of

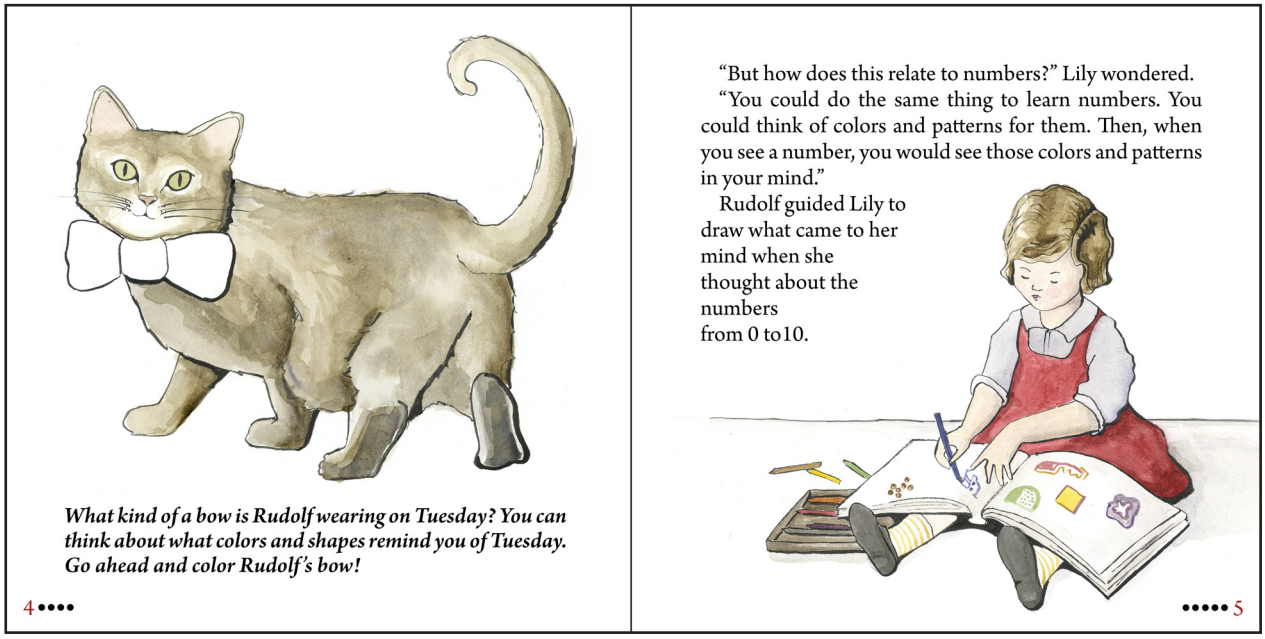


Figure 16: Example of the layout of the book.

the glossiness of the paper, it would be difficult to draw on. After trying out different materials on it, I found that I was able to draw on it with most materials, and although colored pencils did not retain their brightness on it, markers and crayons worked very well.

3.6 Integrating the Theory Into the Production

I wanted to make a very visual production, but there was some controversy in this. The format in which we present information always sets limitations to how we think about that information. Representations are always somewhat biased, and so they do not let the user develop his or her own mental representations which would be most suitable for that individual. This is why I decided to illustrate the book with pictures that reflect the story more than what is actually being learned. As the theoretical framework suggests, it is important that the children create whatever they are learning themselves (see for example Lowenfeld 1947).

Of course, it would have been possible to make a book simply based on the activities. I wanted to integrate the activities into a story because listening to a tale is a more natural way to learn for children as suggested by Steiner pedagogy (Nobel 1991, 250).

My production takes some ideas from both constructivism and radical constructivism. The production emphasizes an active learning process. The learner needs to create through drawing, his or her own perceptions of numbers. Although I don't go as far as radical constructivism to say that we learn nothing through our senses, I have adopted the individualistic tone of radical constructivism. In a sense, the book is only a guide or mentor, and has no value without the learner's activity and individual perceptions.

The influence of the theoretical framework can mostly be seen in the activities. I wanted the children's book to encourage children to freely and intuitively draw their numbers without any templates. In this sense, activity 2 becomes one of the most important tasks of the book. This kind of a method is supported by Steiner, as it allows the intellect and the instinctual, sensual experience to work at the same level (Steiner 1996, 16). This way, children are also allowed to discover an interest out of their own being (Nobel 1991, 250).

Studies on color mediation show that using color in learning can act not only as a cognitive aid, but as a motivational aid as well. (Jones 1962 as described by Otto et al. 1968.) Also, using color mediation as a mental aid in teaching helps children to learn number identification and simple multiplication. (Van Houten & Rolider 1990.) Color mediation is used in the book in

activities 1, 2 and 3. In activity 1 (coloring the bow) the child associates Tuesday to a chosen color or colors. This acts as a preliminary step to activity 2, where these color associations are built by drawing the numbers with colored images. Last, in activity 3 by coloring the indgredients, the children are allowed to mediate the colors not only to the abstract idea of a number, but also to the concrete amount of that number.

Activity number 5 (making the visual map of the numbers) is supported by some of the positive experiences of synesthetes who have the ability to see number-forms in their minds (Van Campen 2008, Tammet 2008). By arranging the numbers that were drawn in activity 2 into a pattern, the students are encouraged to construct imagery on the relationships of the problem, not to visualize concrete details. This was supported by the findings of Hegarty&Krozhenikov (1999). The pattern also allows the child to see the numerical landscape as a whole. The benefit of seeing things as a whole was supported by Steiner (1996, 11–13).

Of course much of the theoretical framework refers to a more philosophical idea underlying the whole production. This is especially the case with the thoughts of Kandinsky who supports the attainment of knowledge through intuitive tasks such as choosing colors to correspond the vibrations of the soul (Kandinsky 1910).

Raami & Mielonen (2012) pose that intuition should be integrated into rational thinking to receive the full benefits of its use. This idea is present throughout the book in the integration of number-sense and intuition. I especially tried to promote this thought in activity number 3. When coloring the ingredients, rational thought is needed to look at the recipe to see how many of each ingredient should be colored, and then counting that amount from the images. Then, intuitive thinking is needed to make the personal color mediations for those amounts. Also, rational and intuitive thinking are mixed in activities 4 (drawing the pattern of the phone number) and activity 5 (making the visual map of the numbers). They both deal with making a holistic pattern. Activity 4 does so from a more rational perspective and activity 5 from a more intuitive perspective.

4. Testing the Book

In this section, I describe the ways in which the children's book was tested, and the observations that resulted. I also discuss the developments that were made to the book based on the results of the testing.

4.1 Methods

I tested the book with 5 children at the International Childcare Education Centre in Herttoniemi. The goals of the testing were to see how the children understand and complete the activities, to define whether the book is suitable for the assigned age group, to examine if the story and illustrations are interesting for the children, to see how the children feel about the book overall and to observe any other noticeable aspect.

I felt that this playschool was a good place to test the books. It is an English language playschool, and since the book is in English it was necessary that the children can understand English well. Also, I found that the playschool uses and appreciates a hands-on approach to learning which suits the ideology of my project well.

I decided to test only 5 books. This was mostly due to financial reasons. Since the book has activities on it, I needed to order one book for each child. It was not possible for me to order large amounts of these books because they were quite expensive to print. Also, I felt that looking at the results of five children would already take quite a lot of time, and I was not planning on an exhaustive review of all the details, but rather

to get an overall idea of what works and what doesn't, or does it work at all.

I discussed the issue with one of the teachers at the playschool. I was planning on testing the book with four to five-year-old children. However, the teacher suggested that a better age range might be five- to six-year-olds, since children at this age have the required amount of patience to listen to a 28-page book and do the activities. Also, their groups were divided into three- to four-year-olds and five- to six-year-olds so it seemed like a good idea to test children from the same group.

We also discussed about how the teacher would pick the five children for the testing. I suggested that she pick children who enjoy drawing, since this is what would certainly be supported by Steiner and Reggio pedagogy (to let children do what comes naturally and what they enjoy). However, after the testing was over, it became evident through a discussion we had that she had picked children who enjoy and who are able to draw. This should be taken in consideration, because it might play a role in the nature of the pictures, for example that many of them are more representative than abstract. Also, as I discussed in my theoretical framework, according to Lowenfeld (1947), adults do not see the world in the same way as children and children who are forced to see the world like adults, might become distressed in their expression. This is not extremely significant to the testing of the books, but it's possible that the results would have been different if the instructor had simply chosen kids who enjoy drawing, regardless of how "good" she saw them to be at it.

4.2 The Testing Session

I tested the book during a single session which took a good hour to do. There were two boys who were both 6-years-old and three girls of whom two were 5-years-old and one was 6-years-old. We were all sitting around a small table. The children were sitting close to each other and could see what the other children were drawing in their books. It would have been ideal if there were separate tables for the kids so that they would have been able to concentrate better on their own work. On the other hand the space was a small separate room where the other kids could not come si it allowed us more privacy. The teacher was also in the room with us but was sitting away from the table, observing the situation from a distance. With us, was also an assistant who helped to make notes and aid the children if they were having difficulty.

Overall, the test situation went very nicely. The children seemed to be interested throughout the session and behaved extremely well. There were no events where I had to tell the children to behave and so we were able to concentrate on the book itself. Next, I will go through the five activities describing the observations made

during the testing session. I was asked that the children remain anonymous, so I will refer to them by numbers 1–5. The age and sex of the children are as follow:

Child #1 : 6-year-old boy

Child #2 : 6-year-old boy

Child #3: 5-year-old girl

Child #4: 6-year-old girl

Child #5: 5-year-old girl

4.3 Results

4.3.1 Coloring the Bow

In this task the children colored Rudolf's bow (figure 17). Four of the five children felt that this was the easiest activity, and this could be seen in the way that they started to color their bows without hesitation. Three children (#2, #3 and #4) colored the bow green, child #5 colored hers violet (a color which she did most of her other activities as well). Only child #1 used more than one color. He made his bow violet, green and orange. He was also the only child who felt that this was not the easiest activity.

Figure 17: Results of the bow activity. From top: child #1, child #5 , child #3.

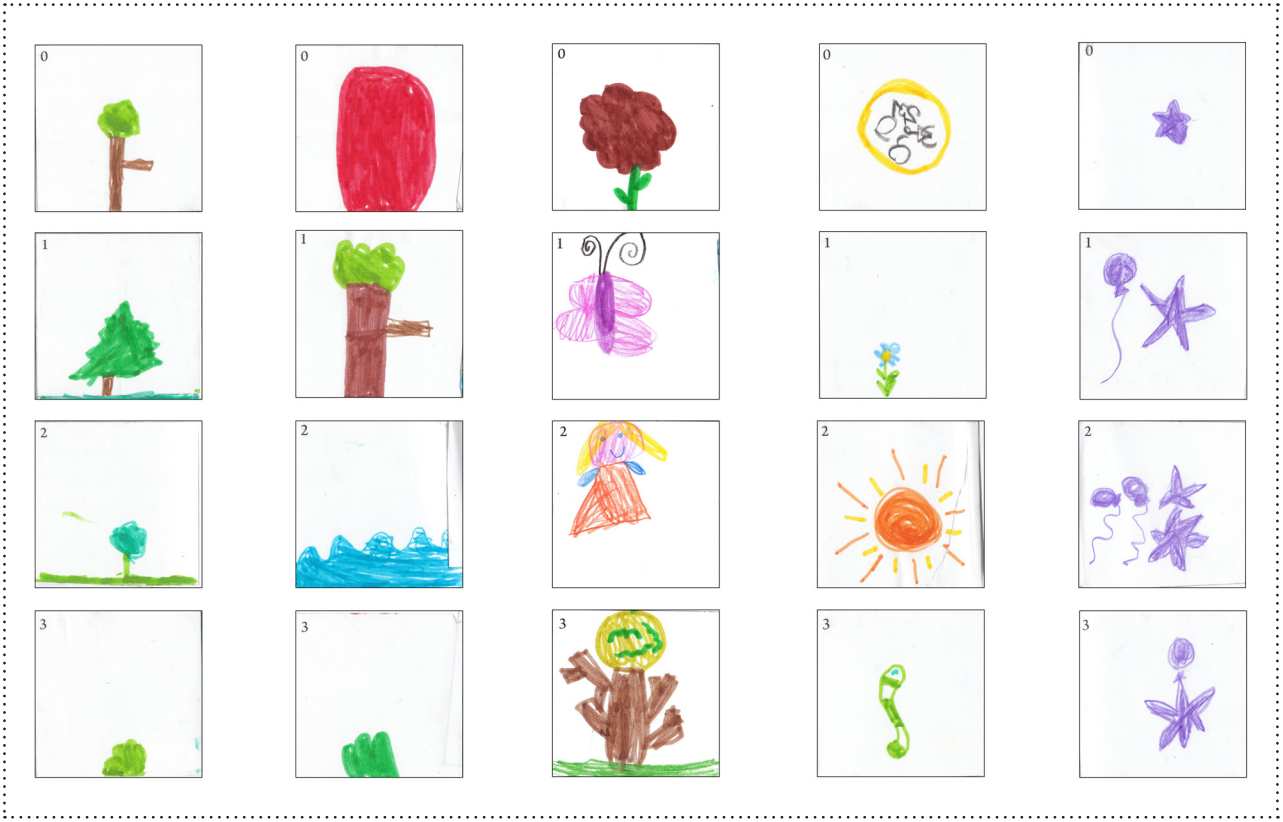
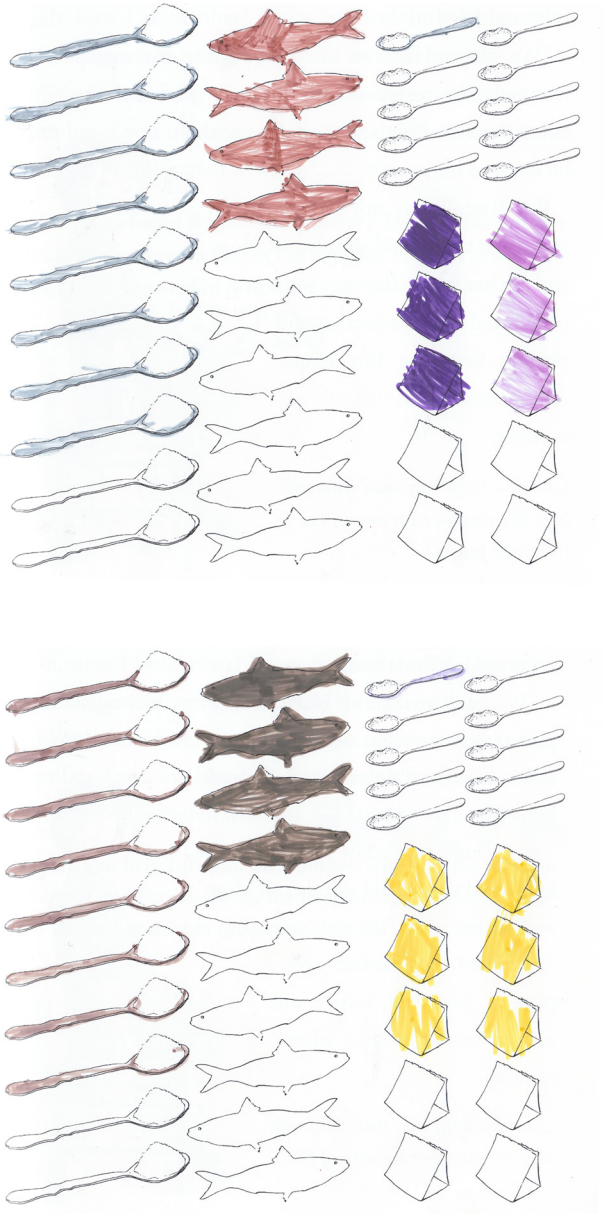


Figure 18: Results of the number imagery activity for the numbers from 0 to 3 (starting from zero on the top row). From right to left: Child #1 – Child #5.

4.3.2 Drawing the Numbers

In this activity the children draw their own number imagery (figure 18). Once I had read the story up until this point I explained how the activity should be done, using the same words as in the instruction in the book. The children did not start drawing right away, so I tried to elaborate the directions by showing them the examples on page 18. First, I was planning on showing the example page only later, during the 5th activity, because I didn't want to steer the drawings into any direction. Yet, I felt the children had not completely understood what to do. This could also just be my own feeling, and that the children simply needed some time to think about what they could draw. I might have been too hesitant in this part. Once the children started drawing they seemed quite enthusiastic and after the session they unanimously felt that this activity, along with the previous bow activity were the most fun.



4.3.3 Coloring the Ingredients

In this activity the children were asked to color the ingredients as seen in the recipe (figure 19). I instructed the children that they could use the same colors here as they did while coloring. However, I only noticed child #3 looking back at the previous activity to see what colors she had used. By observing the pictures I cannot see very many of the same colors in the number drawings and the ingredients. With this activity the children needed some help figuring out how many of each ingredient to draw. All of the children asked this question several times. Child #5 instantly noticed that the eggs were missing.

Figure 19: Examples of the ingredient activity as done by child #5 (top), child #4 (bottom left) and child #3 (right).

4.3.4 Drawing a Pattern of the Number Sequence

The children felt that this was the most difficult activity and I could certainly see the children struggling with it. The object was to draw the pattern that the phone number makes on the keyboard, but this was clearly too difficult. The children easily found the phone number on the first page but seemed to have trouble with what to do with it.

As a result we wrote the number together above the phone, number by number. I then explained that the first three numbers (183) make a triangle and the next four numbers (7297) make another triangle. The children made dots or colored the numbers while we went through them (figure 20), but I'm not convinced that they completely understood the idea of this activity.

4.3.5 Making a Visual Map of the Numbers

For the testing, there were 15 identical square-shaped stickers to be used for activity 2 and 5. In activity 2 there were 6 stickers on one page arranged in a 3x2 shape and 9 stickers on the next page arranged in a 3x3 shape. When the children had to draw on the stickers, there were no problems, but when they were asked to arrange the numbers in the way that they saw them appear in their mind I got similar answers (figure 21). Three of the five children (all the girls) arranged the stickers in a three by three shape on one page with the two numbers left over on the next page. The boys arranged the first six numbers in a 2x3 shape on the first page and then continued on to the next page. Nevertheless, the children seemed to be less hesitant on this task than the previous phone activity, although it was clear that they hadn't exactly understood the problem.

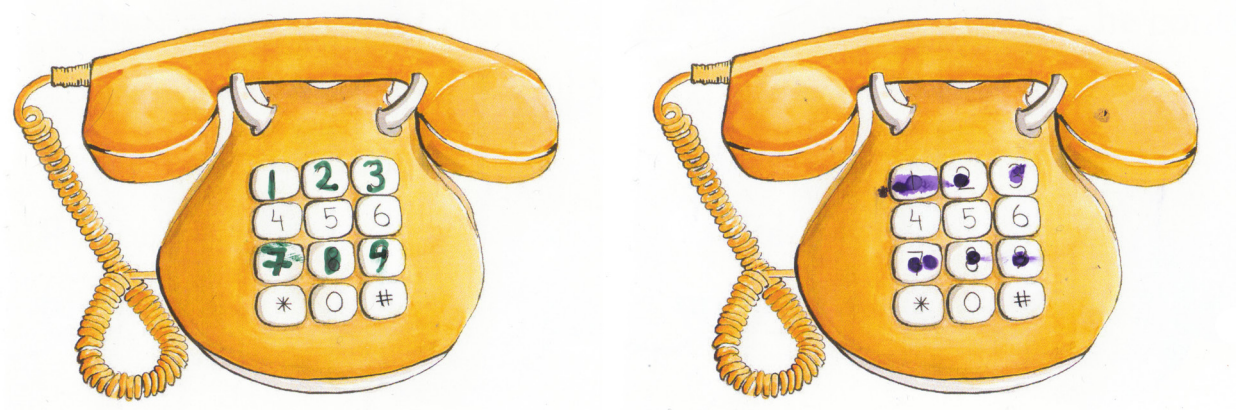


Figure 20: Examples of the phone activity as done by child #2 (left) and child #4 (right).

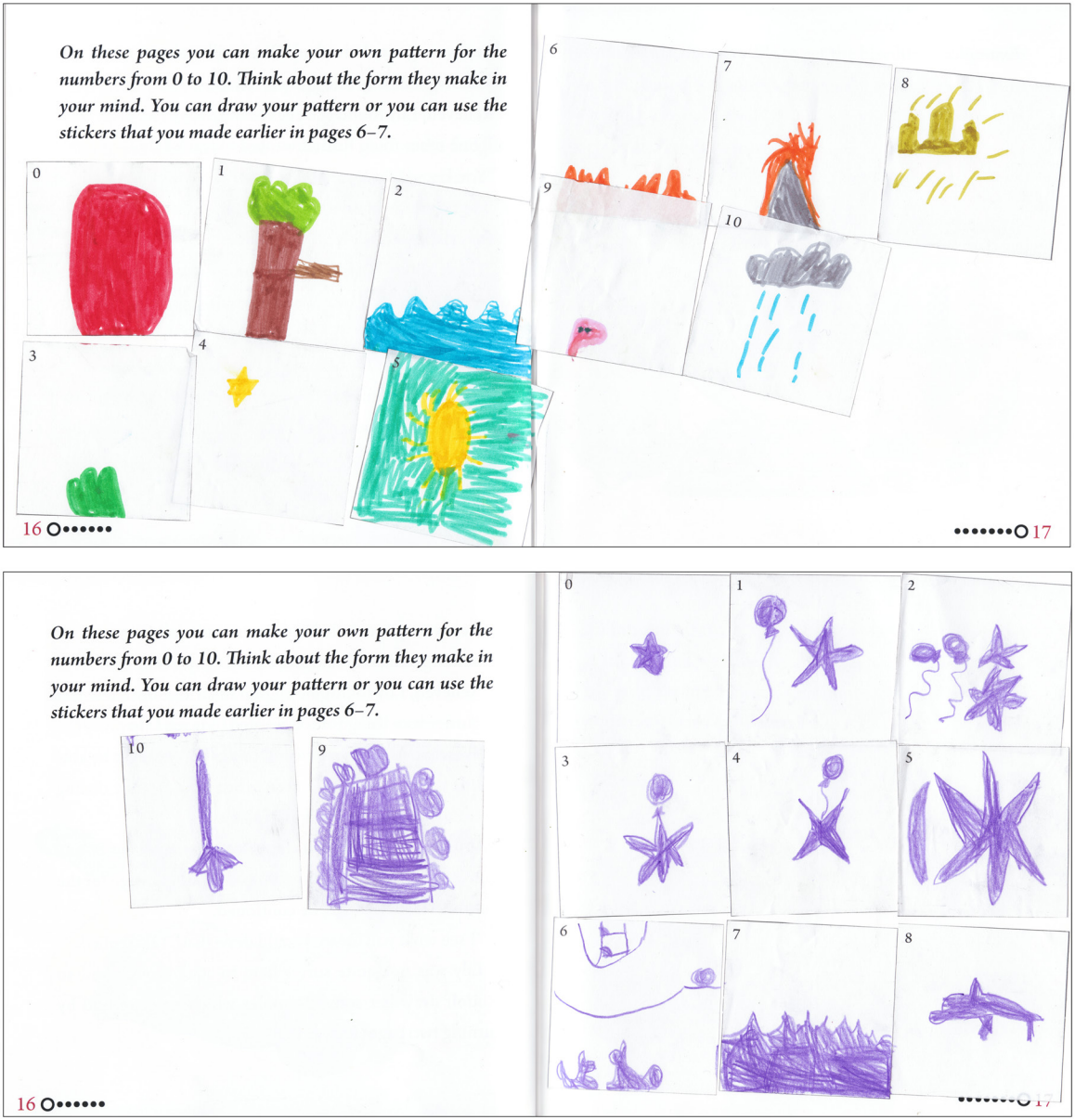


Figure 21: Examples of the ingredient activity as done by child #2 (top) and child #4 (bottom).

4.3.6 Other Observations

The teacher said that she felt the length of the book was suitable for the children considering their age. There was also a good balance between the activities and the story to keep the children interested during the whole session. She did however note that I was not emphasizing the story enough while reading, and that with this age group it would be important to read the book with almost an over-dramatic style. This could be a reason why the children found it hard to follow the last two activities, because to understand them you really need to pay attention to the story as well.

When asked, all the children said that they enjoyed doing the book. One of them commented that it was nice to do something different. I also asked how they chose to draw what they did, and how they chose the colors they used. Child 4 answered "I just did", and child 5 said that she used the colors that she liked. It was difficult to get any more specific answers, but this implies perhaps that they are working largely from their intuition.

4.4 Developments Based on the Testing

Concerning the teachers comment on the way the book was read, I agree that this does affect the way the book will be understood. I do think the book should be understandable regardless of the way it is being read, because this is something I cannot control. I can only make the book in a way that it can be understood as well as possible despite the tone of voice being used with it. It might be that there is still too much instruction integrated in the story. Also, the classroom might not be the best or the most natural environment for the book. The book might be read by a parent to one child. If a parent reads the book to his or her child, then they will have a better understanding of how the child listens and understands.

The biggest problem that the children seemed to have, was understanding the pattern activity at the end of the book and this section definitely needs some improvement. It is possible that the difficulty was due to the bad design of the stickers which were used to arrange the numbers. The stickers worked well for activity 2, but when the children were asked to arrange them, the stickers were very inconvenient.

The way that the children arranged the stickers were almost identical to the way they were initially arranged on pages 6–7 and also resemble the way that the buttons on the phone's keypad are arranged. This was a mistake that I made when I designed the stickers. The space to arrange the stickers is far too small to encourage the children to arrange them in any way they wish. In addition to this, the squared shape of the stickers is inviting for a squared arrangement. Also it was not a good idea to have a ready

arrangement of the stickers on pages 6–7, because this already forms a biased idea for the children, perhaps making them think about how the stickers "should" be arranged. According to these observations I made some improvements. I changed the stickers into individual round ones. I enclosed these individual stickers inside an envelope to avoid any predispositions with the arrangement. Lastly, I made the space on pages 16–17 bigger by making the page into one that opens into additional space, so that there is more space to freely arrange the stickers.

The children also felt that the phone activity was difficult. Therefore, I attempted to make the directions more coherent. At first the instructions said:

"Would you help Lily dial the number? Think of the pattern that the numbers make on the keypad. You can draw it on the keypad or next to the phone."

I then changed this to:

"You can help Lily remember the pattern of the phone number. Color in the buttons of the first three numbers and draw lines to connect them. Do the same for the next four numbers."

Also, it is of course unsure how much the children actually understood the metaphorical nature of drawing the pictures for the numbers. For many, there are some resemblances for the shape of a number and the image that was drawn for it, and this is a good indication that they have thought about the specific number when drawing. For example, when looking at the drawings that child 3 made for the numbers, it seems that she has simply drawn ten pretty pictures. Of course this is a pure guess, but when comparing them with the pictures of child 2 there are no clear indications for this. Child 2 made his zero an oval and his number 3 has three small green round shapes, so these are quite logical and visible clues that there is a resemblance. This is in no way a necessity for the completion of the book, but only a clue for me that the child has understood the task.

5. Conclusion and Discussion

The results of this learning method are difficult to measure because its aim is to develop the child holistically in many dimensions. It would be beneficial for the development of the method to measure the children's understanding of mathematics before and after the use of this learning method. Still, this would only give partial clues to its validity. The change in the intuitive capabilities of the children is much more difficult to analyze. Also, what needs to be taken in consideration is how it motivates the children. I think it is very important that children enjoy learning and that they find it to be a natural process.

This brings me to another aspect that requires attention with the method. It is most probably not beneficial for everyone. I'm sure most people can benefit from the development of intuition and number-sense. Yet, not all people will feel that it is natural to do so through images. The Reggio Emilia approach reminds us to listen to the individual language of the child. Therefore, I think it is important that this visual method is not forced on those who find it more natural to think verbally or kinesthetically. The method could be introduced to those who seem to enjoy drawing and painting.

Despite these challenges, I see many possibilities for this method in education. I was surprised how much support I found for it through the educational perspectives. These "gurus" of pedagogy saw the benefits that aesthetics and

intuition could bring to education, yet many of their ideas have not been taken into use in schools. There is substantial evidence on the benefits of visual cognition to mathematics, yet they view human cognition as an objective process. The subjective, intuitive, or aesthetic qualities which were found to be so integral in the educational approaches of Steiner, Reggio Emilia and constructivism, not to mention the thoughts of Kandinsky, have not been transferred into the studies done in cognitive sciences. Therefore I find that synesthesia could provide us with very interesting possibilities, as it integrates these two separate worlds of ideas.

Through the testing of the book I saw that the children enjoyed doing the activity book with me. This is a positive find, yet there are still many developments that need to be considered in the production. I am hopeful that it is a good start but I also feel that it would require many more testing sessions to be able to make the most suitable version.

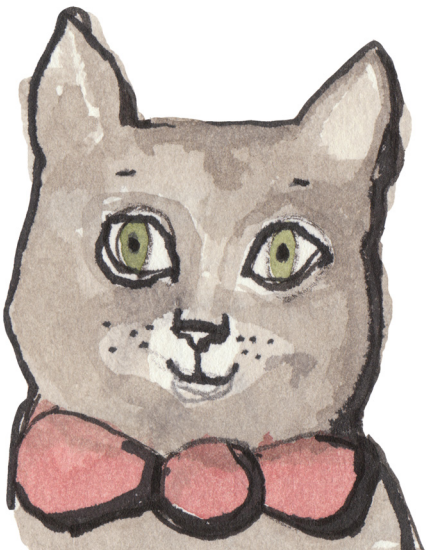
5.1 Further Research and Applications

The children's book is only the first example of how this method might be put into use, and it could be developed further. It is the best I could do with the information in hand. I am positive that with more testing, this kind of a method could be developed to reach good results. This is because I have become convinced through my theoretical framework of the beneficial influence that art can bring to learning. Nevertheless the practical contribution of the book is only a tip of the iceberg.

Thinking about the future possibilities of the study, I could see it leading to fruitful collaboration with researchers in various fields. Society could certainly benefit if artist and designers were integrating their expertise more boldly into seemingly unrelated realms. As designers and artists, we have the potential of making tangible representations of abstract ideas, like I have tried to do with the children's book. Through these representations, researchers in other fields might be able to test ideas that might otherwise seem immeasurable. For example, this study could have benefitted from the contribution of experts in pedagogy. With a background in design I feel that I have the skills to do a case study that mostly tests user experience. The fields of psychology or cognitive sciences could contribute especially in analyzing the mental or emotional elements behind the drawings. I would go as far to say that without more psychological or cognitive studies into my research topic it is very difficult to design further educational material.

In the field of design, I see many opportunities in this subject in interactive media. With interactive technology, it is possible to design educational material where the user might create the initial setting which the program then codes in for

the material. For example, a program could be designed in which a student could first draw images for the numbers. The program could then use these images to produce calculation tasks. The downside of using technology is that the same degree of bodily experience cannot be felt with a two dimensional screen as with concrete materials like a pencil and paper.



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Thanks!

To my thesis supervisor Asta Raami for all the help and encouragement she has given me! I was left with a positive feeling about my work after each discussion we had!

To the wonderful children and staff at the International Childcare Education Center in Herttoniemi

To the many people with whom I had good discussions with in the beginning of this journey: Heidi Paavilainen, Kari Nuutinen, Riitta Vira and Seija Kairavuori.

To my cat Motti, who has never looked down upon me for being a bit stubborn and selfish.

To my husband Juho-Pekka, who kindly holds on to my rope, when I'm flying around in my red kite.